

## CLAIMS

Claim 1. An apparatus for active in situ multi-element gas sparging for accelerated bioremediation or for removal of contaminants in a soil formation containing a subsurface groundwater aquifer, the multi-gas contained in bubbles, said apparatus comprising;

a) a plurality of injection wells each having casing means extending to a depth of a selected aquifer;

b) means for providing an oxidizing agent;

c) means for sizing bubbles;

d) means for controlled mixing of ambient air with said oxidizing agent;

e) means for controlled mixing of ambient air with said oxidizing agent comprising ozone to provide a multi-element gas;

f) means for injecting said multi-element oxidizing gas in said aquifer comprising a plurality of microporous diffusers, without applying a vacuum for extraction biodegradation by-products, wherein said diffusers form micro-fine bubbles containing said multi-element gas that oxidizes in a gas/gas reaction, by stripping, chlorinated hydrocarbons from the aquifer; and

g) agitation means (pulsing or surging) for intermittently agitating water in the well effective to alter the path of micro-fine bubbles through a porous formation whereby enhanced contact between the oxidizing agent contained in each said bubble by stripping pollutant from solution in ambient water into the mini-atmosphere of each bubble for gas/gas reaction is effective to increase the efficiency and speed of remediation of a site.

Claim 2. The apparatus of claim 1 wherein the means for injecting said multi-element oxidizing gas in said aquifer comprises a microporous diffuser for producing bubbles configured to be a direct substitute for a well screen with 30% porosity 5-50 micron channel size resistance to flow only 1 to 3 PSI, capable of handling high volume flow, in combination with a selected annular pack means (sized to formation by means of a test means); said diffuser positioned on end of pipe riser means to reduce residence

time in the riser volume; wherein the size of the micro-fine  
10 bubbles is as set forth in the following table;

SIZE OF BUBBLES

12		UPWARD	TIME (MINUTES) FOR
	BUBBLE	VELOCITY	UPWARDS MIGRATION
14	DIAMETER	IN WATER	(3 METERS) (Coarse Sand and Gravel)
	10mm	.25 m/s	19 min
16	2mm	.16 m/s	30 min
	.2mm	.018 m/s	240 min

Claim 3. The apparatuses of claim 1 wherein the agitation means for  
2 intermittently agitating water in the well effective to alter the  
path of micro-fine bubbles through a solid formation comprises a  
submersible pump

Claim 4. The apparatuses of claim 1 wherein the means for sizing  
micro-fine bubbles micro-fine bubbles containing encapsulated gas  
means comprises a fine bubble production chamber contained in said  
casing means of each injection well.

Claim 5. The apparatuses of claim 4 including the employment of  
specially-designed wellheads to equalize injected flow between  
formations of differing permeability.

Claim 6. The apparatuses of claim 4 including the use of  
alternating pumpage and bubble injection to maximize dispersal of  
bubbles within and outward from specially-designed well casing  
containing a fine bubble production chamber.

Claim 7. An apparatus for active in situ multi-element gas  
sparging for bioremediation for removal contaminants in a soil  
formation containing a subsurface groundwater aquifer, the multi-  
gas contained in bubbles, said apparatus comprising:

a) a plurality of injection wells extending to a depth of a  
selected aquifer;

b) means for providing an oxidizing agent;

c) means for controlled mixing of ambient air with said  
oxidizing agent to provide a multi-element gas;

d) means for injecting said multi-element oxidizing gas in  
said aquifer comprising a plurality of microporous diffusers,

12 without applying a vacuum for extraction biodegradation by-products,  
wherein said diffusers form micro-fine bubbles containing said  
14 multi-element gas that oxidizes, by stripping, chlorinated  
hydrocarbons from the aquifer and surrounding saturated soil  
16 formation into harmless by-products;

e) agitation means for intermittently agitating water in the  
18 well effective to alter the path of micro-fine bubbles through a  
solid formation whereby enhanced contact between the oxidizing  
20 agent contained in each said bubble by stripping pollutant from  
solution in ambient water into the mini-atmosphere of each bubble  
22 effective to increase the efficiency and speed of remediation of a  
site.

23 Claim 8. The system of claim 9 wherein the diffuser means comprises  
24 HDPE porous material with well fittings and pass-through design  
25 which allows individual pressure and flow control wherein  
26 horizontal sparging is permitted with even distribution of air  
27 bubbles.  
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